AIR TRAFFIC CONTROLLER MANPOWER PLANNING MODELLING
A learning platform for understanding the staffing process.

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If you always do what you always did, you will always get what you always got.

Abstract

Air Traffic Controller (ATCO) shortages seem difficult to overcome worldwide. Some aspects of manpower needs are probably considered at too late a stage or their impact is underestimated. An ATCO Manpower Planning (MP) simulation model (LAMPS) has been developed to assess the overall MP process in relation to air traffic demand over a period of 15 years. LAMPS enables the various players/decision makers to increase awareness of the impact of MP policy decisions in the long term, thus providing a learning platform for improved decision making.

Introduction

The main objective of Air Traffic Controller (ATCO) Manpower Planning (MP) is to ensure the provision of the right number of ATCOs, with the right qualification, at the right time and in the right place.

As simple as it reads, it has proved difficult to reach this objective in practice, given the overall perceived shortage of ATCOs, as the following results from surveys show, in Europe and in fact worldwide.

In 1993, the Select Group for Assessing Manpower Issues (SGAMI) reported an average shortage of ATCOs in 20 European States of 9% in 1993, 7% in 1994, 5% in 1995, 2% in 1996 and a surplus of 0.4% in 1997 (EATCHIP 1993).

However, in 1997 an update of the SGAMI survey of 1993 showed a real shortage overall over the period 1993 – 1997 of 9%, a forecast over the period 1998 – 2002 showed an overall shortage of 3.5% (EATCHIP 1998c).

In 2000, in a survey on required/available ATCOs, 18 European States reported ATCO shortages of 13% in 2000, 12% in 2001, 10% in 2002, 7% in 2003 and 6% in 2004 (EATMP 2000). This result cannot be directly compared with the previous surveys, as the composition of participating States is slightly different, but the message remains the same: the real gap between what is required and what is available was either not detected or was in fact not expected.

Depending when it is measured, it is nevertheless astonishing how different the perception is between required and available ATCOs. To a certain extent, these shortages can be translated into reduced time for training activities and increased air traffic delays, thus putting pressure on the current ATCO workforce. Possibly deteriorating working conditions and increasing delays even further, making it a vicious circle. What does it reveal about the MP process? Is it too short-term? Is the MP process too static? Are the training possibilities so low that making up the shortfall is not feasible?

A Different View on MP

The desired outcome of MP is to provide a sufficient number of qualified personnel for air navigation services on a timely basis, to ensure the safe, orderly and expeditious handling of air traffic in the first place and, secondly, to provide personnel for all other ATCO tasks. Even the posts considered necessary to be filled by staff with an ATCO background have to be taken into account when assessing overall ATCO requirements. The process by which this outcome is achieved can be expressed as dynamic decision making.
Brehmer (1990, 1992) considers the dynamic decision making process as the process of achieving control over a system in order to produce a desired outcome. In order to control the system, decision-makers must have a mental model of the dynamics they seek to control. Mental models are the mechanisms whereby humans are able to generate descriptions of the system purpose, explain system functions, and predict future system states. One conclusion from research and practice is that people can make better (and more informed) decisions in a dynamic environment, when they have a more complete model of the system and thus know better how the system is composed and how parts of the system are linked together and in fact interact.

Many problems concerned with MP are not easily described in written documents and thus are of no real help. The documents themselves tend to match in complexity the problems they are supposed to solve. The reason is that the complexity and dynamics involved in planning, and how in practice to cope with both, cannot be presented in a static manner.

Another way of dealing with the complexity and dynamics in ATM is using a modelling tool to conceptualise, document, simulate, analyse and optimise a MP model. The aim of the developed model, LAMPS (Long-term ATCO Manpower Planning Simulation), is to provide greater insight into the behaviour of different events within MP and to explore the causes and effects that lead to these events. All management levels, from the Director managing a Centre, to the individual ATCO managing air traffic from the position, can learn from and create a better understanding of the system they are handling if they would get a deeper insight into the processes and the behaviour of the interlinked sub-systems in MP.

With LAMPS the manpower planner(s) (MPs) can provide such a learning environment, in the sense that all players in the MP process, normally having only a limited view of the system as a whole, learn to view the system as a whole, identifying their part and understanding its impact on the system.

Modelling Tool

LAMPS is built using dynamic modelling software called VENSIM (VENtana SIMulation environment)[1] and SABLE[2] front-end software. The software allows the analyst to execute a complete System Dynamic (SD) project from initial set-up through to simulation and analysis. The developer is provided with a powerful array of graphical and analytical tools to facilitate the tracing of system behaviour to causal influences and, ultimately, input the necessary data under control of the user. A model consists of various views of the system. Diagrams are constructed for each element of the view, describing its relationship with other elements. The relationships are further quantified by equations.

Verification and Validation

[1] VENSIM™ is a trademark of VENTANA SYSTEMS, INC., HARVARD, Massachusetts.
[2] SABLE™ is a trademark of VENTANA SYSTEMS UK Ltd., Eastleigh, Hampshire, UK.

Coyle (1996) defines validity of a model as "well-suited to its purpose and soundly constructed". His key philosophy is that "the model should do the same things as the real system *and for the same reasons*". LAMPS has been tested by three European ATM providers to verify this. These tests stated that the LAMPS tool reflects the current manpower planning practise and is consequently well suited to one of its purpose to mirror and understand the current practices employed in ATCO MP. As there are no objective standards with regard to MP, validation has to be done by using the tool over time and to establish its suitebality for the purpose of achiving a better balance between ATCOs required and available at any time. Once validated the model will be further developed into a decision making support tool.

From Static Descriptions to Dynamic MP Modelling

The purpose of this modelling is to provide the decision maker with a better understanding of the real problems he or she has to cope with, and not to replace the decision maker, or make a complex reality even more complex.

Air Traffic Demand

In simple terms, the airspace entrusted to an ATS provider is divided into control sectors containing consoles for an executive control position, a planning control position and, if necessary, an assistant control position. From these positions ATCOs organise a safe, orderly and expeditious flow of traffic. Consequently, the air traffic demand drives the number of positions to be manned and the number of hours control positions must be open. These opening hours for positions can vary from day to day, from weekday to weekend day and from season to season. There are occasional irregular peaks in demand, which occur at the start and end of the holiday season, before and after a European Cup final, etc.
Based on the actual opening and closing times of sectors, various OR (Operational Requirement) profiles can be derived. Normally the OR over a certain period of time is calculated from the average opening and closing times, rather than the peak requirements. Once the OR has been established, it forms the basis for the calculation of the number of ATCOs needed. It must be emphasised that this basis is the most important factor in MP, as it is the cornerstone of the manpower need. From the viewpoint of cost, it should be established in an appropriate manner.

Calculation of Required Manpower

In Annex A of the deliverable "ATS Manpower Planning in Practice: Introduction to a Qualitative and Quantitative Staffing Methodology" (EATCHIP, 1998c), two calculation methods for the required manpower are explained in detail. As well as these two methods, other approaches exist. It will be a challenge for ATS providers throughout the European Civil Aviation Conference (ECAC) region to arrive at a clearly understood transparent and effective way of calculating the OR and hence the required manpower.

LAMPS integrates three approaches in MP; one by which the manpower required is driven by the traffic demand and its growth over time, the other by which the manpower required is driven by the OR, adjusted over time if the increase in air traffic demand reaches a certain point at which more ATCOs should be available and the manpower required by the number of duties as reflected in a duty roster. Each approach can be considered separately. The dynamic change in traffic demand over time and its consequent effect on the number of ATCOs required is mapped on to the number of ATCOs available. This availability is determined by the in-flow, through-flow and out-flow of ATCOs.

The following Figure 1 shows the relation between air traffic demand and the way the requirement of ATCOs is determined from that demand in the current LAMPS model.

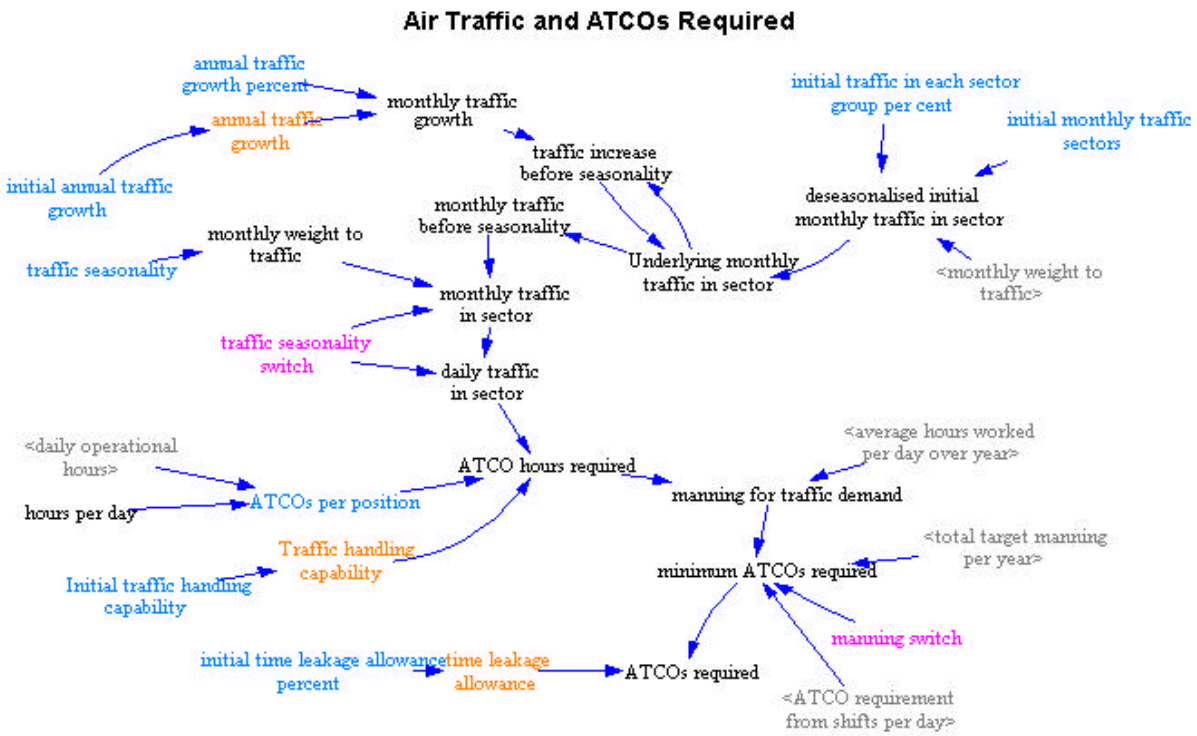


Figure 1. Air Traffic demand and ATCOs required.

Traffic is controlled by so-called Sector Groups, which consist of a number of individual Sectors manned by an executive ATCO and, normally, a planning ATCO. The initial monthly traffic for all Sector Groups has consequently to be adapted for the part of traffic flying through more than one Sector Group and for seasonality.

Taking that into account, the daily traffic in a Sector Group averaged out over a 24 hours period is determined. Based on that it is determined how much ATCO hours are required, in conjunction with the Traffic Handling capability - i.e. the number of aircraft movements a Sector Group can handle - to cope with that traffic on a monthly basis.

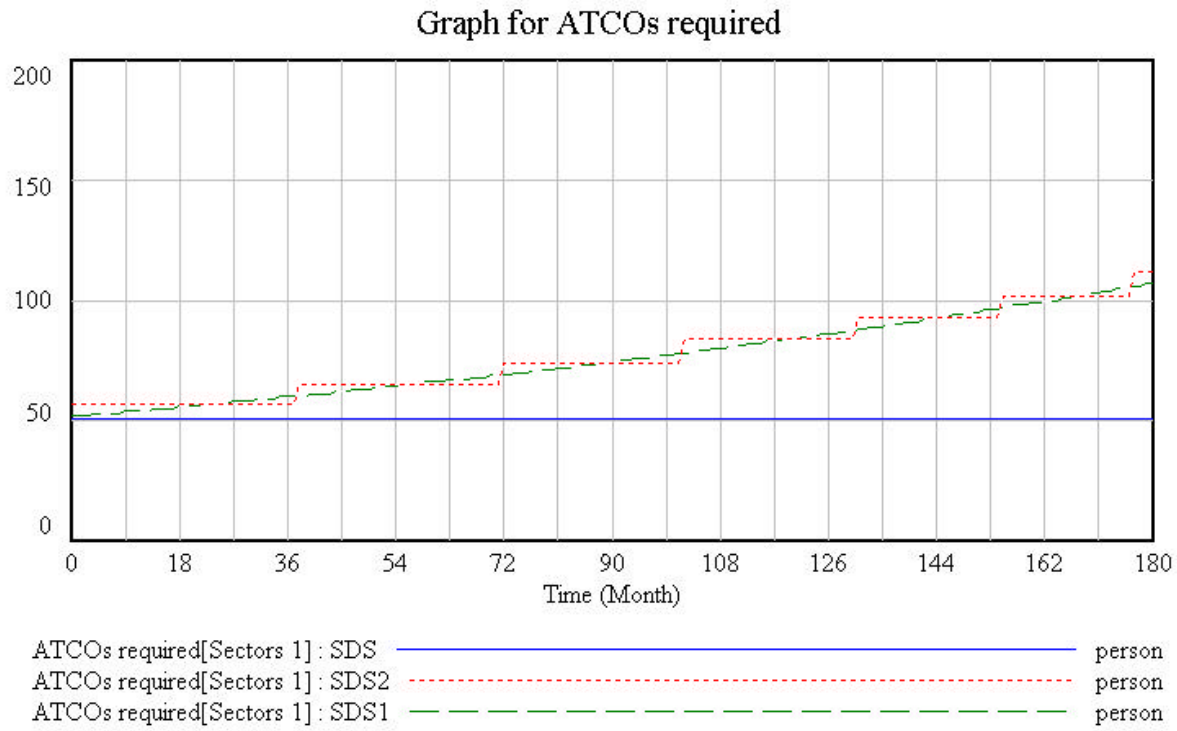
Depending on the “manning switch” it is calculated how many ATCOs are required on a yearly basis if:

- the number of ATCOs required should follow the air traffic demand,

- the number of ATCOs required should follow the earlier explained Operational Requirement or

- the number of ATCOs required should follow the number of duties to perform each day.

The following Graph 1 shows the result for an imaginary Sector Group 1.



Graph 1: ATCOs required for Sector Group 1

The (green) striped line shows the requirement for ATCOs following the development of air traffic demand (in this example increasing with 5% per year).
The (red) dotted line shows the requirement for ATCOs following the Operational Requirement, the number of control hours needed being automatically adjusted by the model.
The (blue) straight line shows the requirement for ATCOs following the number of duties in the monthly duty roster needed to cover the air traffic demand.

The latter doesn't change over time, as it is constant and can only be changed via gaming or by entering a time series of different number of duties as external data.

As the training from *Ab initio* ATCO to fully licensed ATCO may take three to four years, it is very important to know the requirement of ATCOs compared to the available ones over a longer time period.

The methodology of determination of the required number of ATCOs over time is still under consideration by various Air Traffic Service Providers, and the way demonstrated here is an approach to stimulate awareness and discussion.

Balancing In-flow, Through-flow and Out-flow

For control systems to be functional the relationship between what is registered as input and assessed as output has to be clarified. In general four classes of functional relationship exist:

- **Deterministic**: the interaction between input and output can be defined precisely. Examples: number of hours worked, cost of employment.

- **Probabilistic**: a complex linear or non-linear relationship exists that fluctuates randomly across a range of values. Examples: the relationship between the number of *ab initio* trainees accepted

by an ATS Academy, the number of licensed controllers that emerge with a rating, due to the probability of failing during training.

- **Dynamic**: multiple specific inputs have to be present before an output can at all be determined. Very often there will be a time lag before the 'true' relationship becomes evident. Example: deterioration of working conditions and social climate may influence the perceived outflow of ATCOs, e.g. resignations and/or requests for transfer.

- **Static**: data like the number of training places, On-the-Job training possibilities, in general, data that does not change over time or is only occasionally adjusted.

All four relationships need to be considered together to balance over time the required number of ATCOs with the available number of ATCOs. Any discrepancy between the two is reflected in either a controller surplus, which, if too high, might be considered uneconomical, or controller shortage, which might lead to overtime worked, delayed traffic and, if delay exceeds a certain level, unsatisfied traffic.

The in-flow, through-flow and out-flow of ATCOs is modelled in LAMPS in a similar way as the ATCO requirement part, taking into account issues as;

- Training cycles,
- ATCOs availability, after leave, training, sickness, other absences from the Operations room,
- the probability of maternity and paternity leave,
- the probability of outflow through invalidity and death,
- part-time work,
- yearly distribution of leave and sickness days,
- age distribution,
- retirements,
- etc.

In the context of this paper it would go too far to try to show all the other views of the LAMPS model in which the in-flow, through-flow and out-flow is modelled.

An example

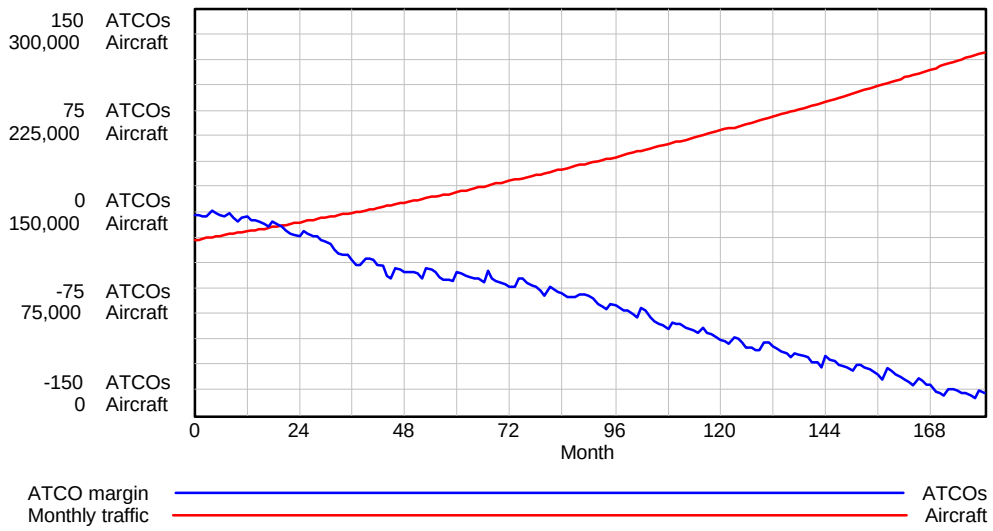
As traffic grows, ATCO shortages may arise because the number of *ab initios* that can enter academy training is constrained by the number of training places available or because insufficient positions are available in the simulator or OJT. The question to address is WHEN and HOW MUCH additional places or positions need to be supplied.

The following assumptions are made in this example:
- 15 places are available for each intake entering academy training.
- the period between intakes is 7 months.
- 12 position possibilities in the simulator.
- 3 Sectors Groups are in use, and 4 people can receive OJT in Sector Group 1, 4 in Sector Group 2, and 2 in Sector Group 3.
- Traffic is growing at a rate of 5% per annum.

It is assumed here, for ease of demonstration, that all other system variables have been widely discussed and considered viable.

LAMPS can be run to show how the monthly ATCO margin changes over a period of 15 years. The margin is the difference between the number of ATCOs employed and the number required to handle the traffic volume. It becomes negative when there is an ATCO shortage. The following

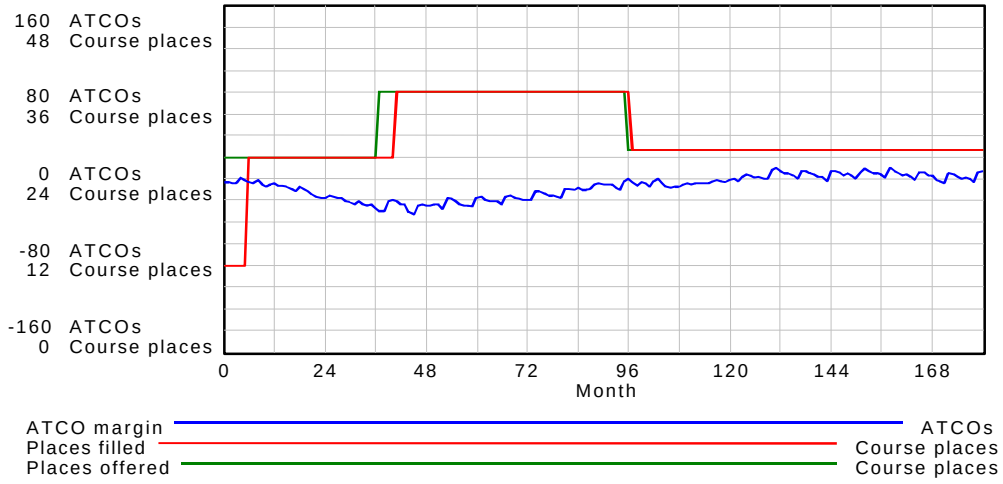
Graph 2 shows the situation using the assumptions listed above. The ATCO margin has been aggregated across the three sector groups. It shows that the number of ATCOs employed meets the requirement at the beginning of the simulated period but that a shortage develops after eighteen months, which grows further as the traffic volume grows.



Graph 2 – Monthly traffic and ATCO margin

Please note that the situation in Graph 2 would arise if one would continue as described in the assumptions. LAMPS can now be used to create scenarios and simulate them to avoid the shortage.

Result



Graph 3 - Two levels of institutional course places offered and filled

As shown in Graph 3 above, the result is that by running various scenario's and probing various combinations of training places/positions the following scenario seems to hold: increasing the number of training places to 27 for three years, increasing it then to 36, reducing it to 28 after 8 years for the remainder of the simulation; increasing the number of simulator positions to 18 after two years and to 26 positions after 5 years and increasing the number of OJT positions to 5,6,5 after thirty months. This scenario provides a good balance around the ATCO margin zero line.

LAMPS as a Learning Platform

It was also recognised that to implement the LAMPS tool in an ATM organisation and to realise the maximum benefits of providing a "modelling and simulating for learning" platform required that the tool is embedded within a collaborative process, thus, enabling an improvement in how ATCO manpower planning issues are discussed and to avoid isolated solutions been taken. In this context see the paper of Una Mellett, “A Strategic and Integrated Approach to Human Issues in Air Traffic Management”, discussing this collaborative approach called CHAMP (Collaborative and Harmonised ATCO Manpower planning Process).

Benefits

What we have achieved in this new approach for ATCO staff planning is a shift from a number crunching, isolated, short term, reactive process to an integrated, strategic approach embedded in a collaborative process which brings all players together to plan and decide on solutions to staffing issues. The main benefits of this approach are:

- LAMPS by modelling the flow of ATCOs through the ATM system offers a framework to communicate about dynamic complexities and interdependencies of the many variables influencing ATCOs required with ATCOs available.

- Focusing on the internal structure of the processes for ATCO in-flow, through-flow and out-flow enhances the possibilities of identifying the root causes of problems. This should result in solutions, which can have long-term positive impact rather then short-term ineffective quick fixes.

- Simulating scenario’s enables the many players involved in staff planning to debate the implications of policy change and to link an ATM’s performance (e.g. meeting traffic demand) to its operating structure (e.g. staff planning processes).

- CHAMP by providing staff planners with skills and processes to work with other players involved in staff planning is building a shared understanding of strategic issues in staffing by closely examining and discussing "what if" scenario’s.

Thus, LAMPS through the CHAMP process enables the players involved in staff planning to structure informed debate about staffing issues. Therefore, the long-term benefit is that decision making on staff planning issues within ATM organisations will improve.

The introduction of this approach during an information session for Air Traffic Management Organisations over Europe in November 2000 in Brussels has attracted a lot of interest and resulted in pilot projects for implementing this approach in Denmark, the Netherlands, the CEATS States (i.e., Austria, Bosnia and Herzegovina, Croatia, Czech Republic, Hungary, Italy, Slovak Republic and Slovenia) and the Maastricht UAC of EUROCONTROL.

Linked to these pilots is an overall review of the model in order to adapt in a generic way to the slight differences in the ATCO Manpower practices in the organisations mentioned above and to establish a better defined validation process than the one mentioned before.

The results of these pilot projects are envisaged to be available in the beginning of 2003.

Conclusion

In conclusion, LAMPS, embedded in a collaborative process, provides a learning platform to enable all players in the MP process to involve themselves actively in this process, where pro-active and more integrated MP policies can emerge. This should improve the decision making process for ATCO MP and allow for a better balance between anticipated ATCO requirements and availability.

This also is an example where experts, covering a variety of expertise, can come together to give their inputs into the LAMPS model, to widen its use and applicability for the overall benefit of the ATM community.

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Curriculum-Vitae

Cees Niesing is a Human Resources Expert. He started off his career in 1964 in the Dutch Royal Air Force where he was involved in financial and logistic matters. He joined the Maastricht UAC of EUROCONTROL in 1973 where he has been working in the Personnel Section until he joined the Human Factors and Manpower Unit of EATMP (European Air Traffic Management Programme) in January 1997. He is the Work Package Leader for advanced MP Methods and Tools in the Manpower Sub-Programme of the Human Resources Programme.

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